



Introduce Computer Engineering to Middle School Students through a Science Project

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Introduce Computer Engineering to Middle School Students through a Science Project

Abstract

Computer Engineering is a relative new program among all the engineering programs. With the fast developing pace of computer industry, people with Computer Engineering skills are of high demand. But because it is new and mainly hidden behind Computer Science, or Electrical Engineering programs in major choices, not very much students realize the beauty of it. In this paper, the authors, who are university professors, share the experiences of supporting a local middle school's science project, and at the meanwhile introduce Computer Engineering program through the project. Positive students' surveys support the success of this implementation.

Introduction

To tackle the low enrollment and high drop rates challenge that the engineering education is facing nowadays, more and more university faculty members try to collaborate with K-12 educators, and go to high school or middle school classes to introduce basic science and engineering concepts. This has been proved to be effective to attract talented students into STEM majors at an early age [1,2,3]. In the meantime, middle/high school students are surrounded by video games, robotics, internet, and other fascinating new inventions in the past decades. They are already anxious about using the cutting-edge technologies to explore the outside world at high school or even middle school stage [4,5,6]. To answer the demands from this new generation students, an increasing number of K-12 math and science teachers are searching for technical support from higher educational institutions to generate new exciting science projects to stimulate the curious youngsters. The demands from educators of both sides tie them together in establishing a collaboration platform which will benefit both parties. There exist three key aspects in the promising platform: first, the challenging science projects at middle/high school to stimulate students' interests; second, the dedicate university supporters; and third, the close connection between higher education and middle/high schools.

Background

Middle School

In this collaboration project, the middle school is one of the NASA Explorer Schools in a metropolitan area. Having one astronaut graduated from this middle school, the whole school is very proud of being involved in exploring the space. Both the administrators and teachers are doing their best to broaden students' view towards the outer space. As one example, each summer, they send students to NASA for training and competition. The school's explorer club (roughly enrollment of 60 students per semester), usually meet after classes and work on various science project throughout the whole school year. Recently, they connected to space station and talked to astronaut in real time. Students were able to ask their own interested questions directly to astronauts and get answers from space station. All kinds of activities fostered students to reach out, but none of the detailed computer programming or related skills were introduced in their curricula or in after school club.

Weather Balloon Project

For the past academic year, the school science teacher focused on a weather balloon launching project which will send balloon to the near space layer (65,000 to 325,000 feet above sea level) to collect real data. Fig. 1 shows a picture taken from near space layer, and Fig. 2 plots the air pressure changing with altitude.



Fig. 1 A picture taken of the inky blackness of space and the curvature of the Earth

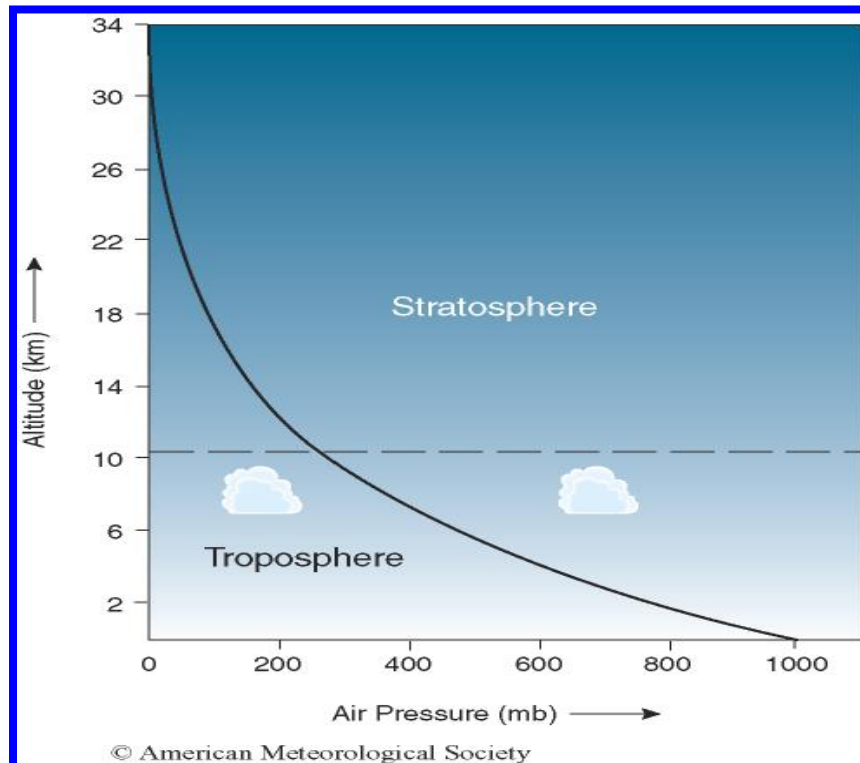


Fig. 2 Average air pressure variation with altitude expressed in mb

It was a very interesting project and the beauty of the near space attracted all the students' attention. Hence it was a big challenge for middle school teachers to implement it all by themselves. Besides the lacking of funding, the system design required not only physics knowledge, but also computer techniques to record data obtained from the balloon.

Prairie View A&M University

Prairie View A&M University (PVAMU) is the second oldest higher education institution in Texas founded in 1876. With an established reputation for producing engineers, nurses, and educators, PVAMU offers baccalaureate degrees in 50 academic majors, 37 master's degrees and four doctoral degree programs through nine colleges and schools. The university is accredited by the Southern Association of Colleges and Schools as a comprehensive public institution of higher education authorized to award Bachelor's, Master's and Doctoral degrees. The College of Engineering (COE) consists of six departments—Chemical Engineering, Civil Engineering, Computer Science, Electrical and Computer Engineering, Engineering Technology, and Mechanical Engineering. All the degree programs in the College are ABET accredited. Total of eight BS degrees are offered by the above six departments: Chemical Engineering (CHEG), Civil Engineering (CVEG), Computer Science (CS), Electrical Engineering (ELEG), Computer Engineering (CPEG), Electrical Engineering Technology (ELET), Computer Engineering Technology (CPET), and Mechanical Engineering (MECG). With the growing engineering program, PVAMU widely get involved in K-12 educational collaboration. Authors of this paper obtained external funding from NSF and Texas Workforce. Funded projects include summer camps, school visits, and sponsoring competitions.

In another project meeting, the middle school science teacher met with a professor of PVAMU and asked for help. Quickly PVAMU formed a group of faculty members from departments of Physics, Electrical and Computer Engineering, and Computer Engineering Technology. With the expertise and experiences on leading similar projects, university professors arranged meetings with middle school science teachers; suggested external funding resources; and provided technical supports.

- University faculty hosted several meetings for project discussion to make sure two parties were on the same page.
- It was suggested by university faculty to the middle school teachers to apply external funding. The proposal was successfully funded of \$1500 on purchasing the equipment.
- The system design was assisted by university faculty and the most important part of the system was the microprocessor to control the collecting of data.

During the project implementation, university faculty observed the necessity of introducing Computer Engineering program to the middle school students since microcontroller and embedded microcomputer were frequently asked and they were very good examples to illustrate Computer Engineering program.

Computer Engineering Program

As a relative new program, CPEG has been traditionally viewed as a combination of Computer Science and Electrical Engineering [7]. Computer engineers usually have training in electrical engineering, software design and hardware-software integration instead of only software engineering or electrical engineering. For PVAMU, CPEG is the newest program in College of Engineering and just received its initial ABET accreditation. It has been studied that there are

two main reasons hindering the enrollment of CPEG program. The first one is the difficulty of the courses in the degree plan since it picks core courses from the two programs—electrical engineering and computer science. The second reason is there are not so many people notice the existence of the program. In order to introduce CPEG to more and more youngsters, faculty from PVAMU used this opportunity to show the middle school students how a typical computer engineering project can solve science and engineering problems.

Project Implementation

To implement this weather balloon project, both university professors and middle school teachers had a thorough discussion to choose the proper equipment and software platform. Because of the budget limitation, a low cost microcontroller was chosen to be the core of the data collection system. Several sensors were added to measure the temperature, humidity, latitude, altitude and so on. A digital camera was mounted to take pictures during the launch. Luckily there are similar products in the market. So it was decided to adopt “BalloonSat Extreme” from NearSys for this project. BalloonSat Extreme is designed for people with computer programming and electrical circuit knowledge. It is under \$100 per kit, so the users have to solder all the circuit on the board. It chooses BASIC Stamp microcontroller from Parallax, which is one of the most popular microcontrollers in the market. In the project, the hands-on experiment greatly helped the students in quickly understanding how computer hardware and software work, which is much superior to simply reading examples in textbooks. But the technical requirement goes beyond middle school level.

In order to fulfill middle school students’ dream of space exploration, university professors volunteered to donate their time and effort to build and test the system, also taught middle school counterpart the procedure step by step. Although the circuit (as shown in Fig. 3) and programming (Fig. 4 shows program downloading) parts were too advanced for the students to totally understand all the details, they were engaged by the excitement of data collection through various sensors and the information transmission to the microcontroller (Fig. 5 illustrates the data retrieving from memory). For most of them, it was the first time to see how a computer driven data acquisition system can be built in front of their eyes.

During this project, the concept of STEM (science, technology, engineering, and mathematics) was also introduced to the middle school students by university professors through presentation. A brief history of computer technology and the current fancy applications were brought into students’ attention. At the end, students gave positive feedbacks. For example, some students wrote comments “Thank you for helping us know what all of this things means” “Thank you for giving us some of your time” and “Thanks for showing us more about Computer Engineering”. From students’ smile, you can say all the hardship is worthwhile. And this collaboration model—university professors together with middle school science teachers—will also benefit the community in educating the community about the nature of STEM, as well as a fairly new program—Computer Engineering.

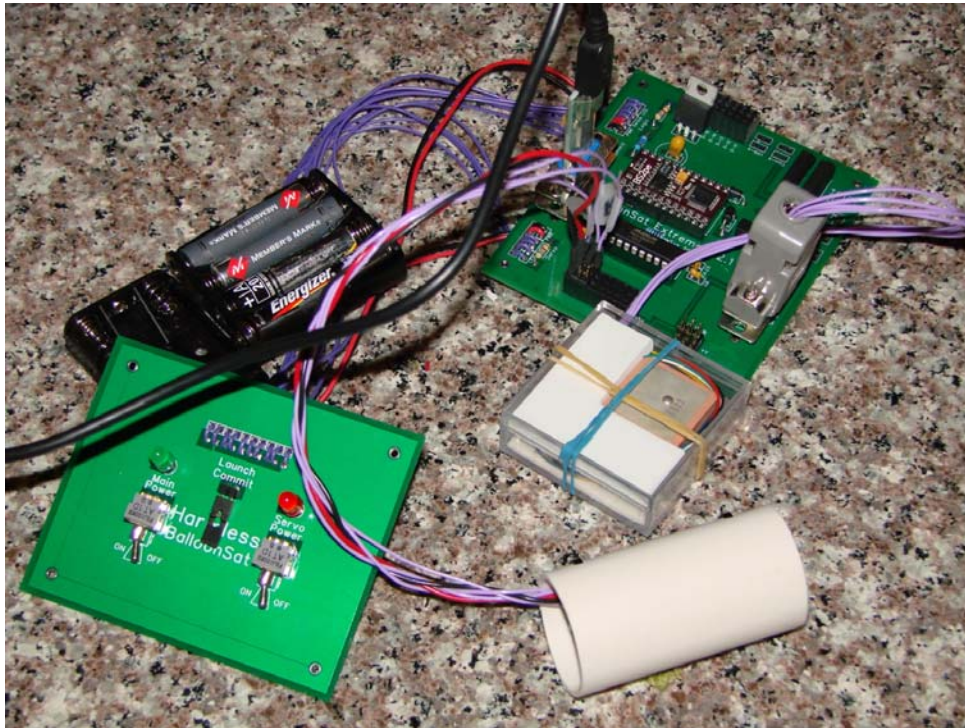


Fig. 3 BalloonSat Extreme system hardware

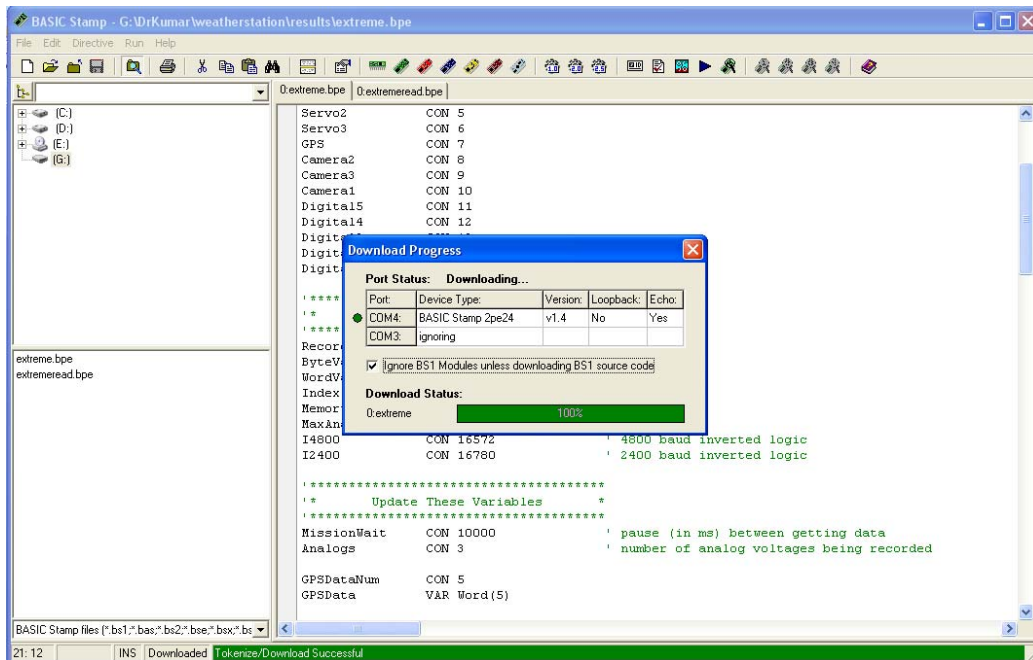


Fig. 4 Download program to BASIC Stamp microcontroller

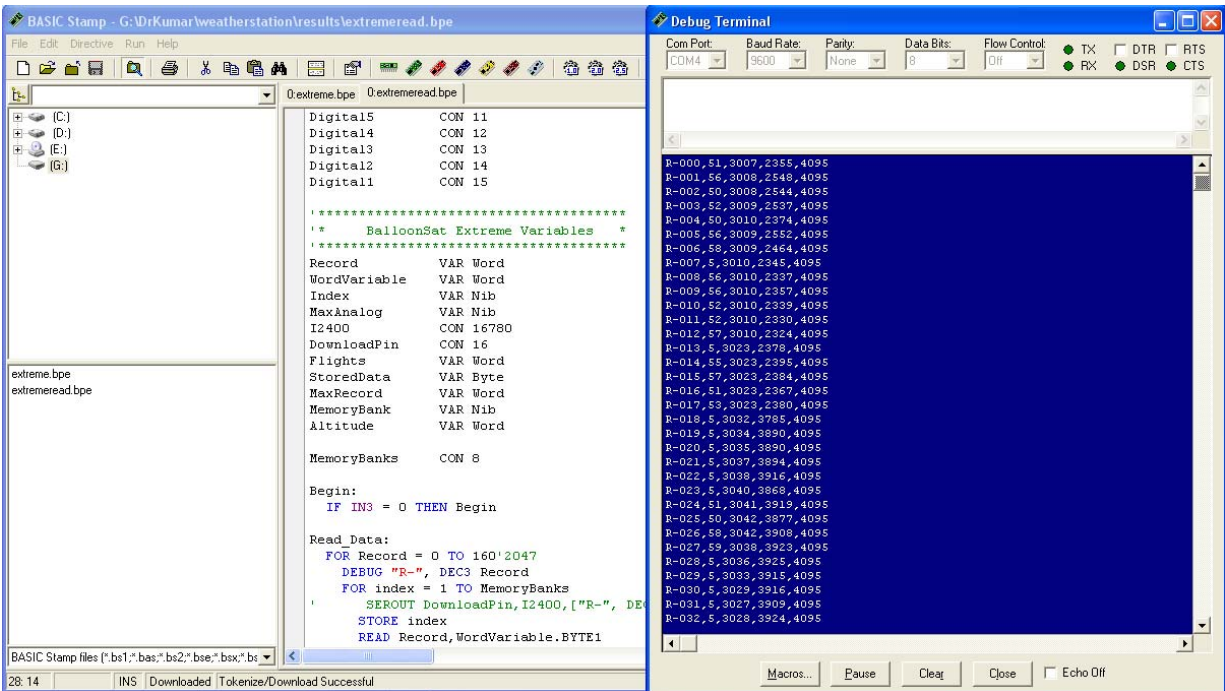


Fig. 5 Data (temperature, height, GPS) retrieved from BalloonSat Extreme

Survey Results

This project not only benefits middle school students to acquire knowledge in physics and engineering, but also provides university [8,9,10] professors a good opportunity to observe why STEM programs are facing enrollment problems. The workforce is in great needs of graduates in computing majors, while to the country, the enrollment and graduating rate are declining for the past decades. What might be the reason and possible cure? University professors would like to learn from the results of this project. So a survey of seven questions was designed to clarify some of the problems. The same survey was given to the same group of students at the beginning and the end of the project.

This survey was aiming at verifying this project's impact on middle school students' understanding of STEM and CPEG program. The survey questions are shown in Fig. 6. The survey results are presented in Fig. 7. Here "Strongly Agree" and "Agree" which are rated five and four in the survey are compared before and after the project for all the seven questions. All of them got more positive feedback after the implementation of the project. It is very interesting that the first five questions received more significant rise.

Weather Balloon Project Questionnaire

Consider each of the following statements. Please indicate which category best describes your agreement with each statement. (Use 5 as the most agree and 1 as the least agree.)

Statements	Level of Agreement				
	5	4	3	2	1
1. I know what “Computer Engineering” means.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. I know that “microcontroller” is widely used in our daily lives.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. I know “STEM” means science, technology, engineering, and mathematics.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. I’ll think about choosing “STEM” related major in the future.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. I’d like to learn more about how computer hardware and software work together to make things done.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. I’d like to participate in more science and engineering project like this one.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. I am interested in learning more about science and consider a major in Physics or Chemistry.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<p>Could you give an example on Computer Engineering application?</p> <p>Other comments:</p>					

Fig. 6 Survey questions

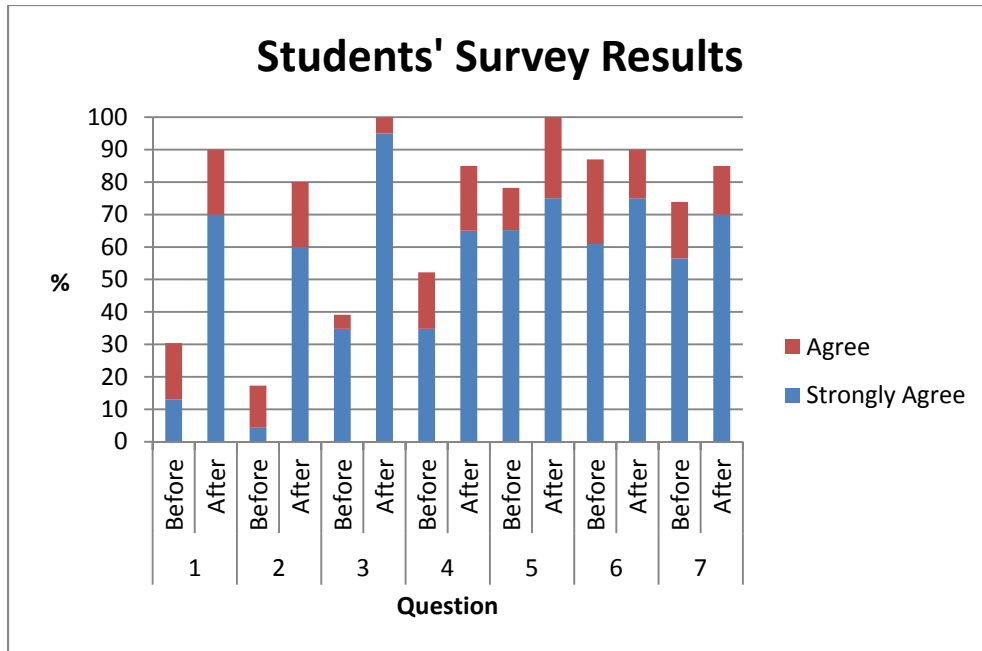


Fig. 7 Survey Statistics

Conclusions

After completion of this project, there are so many findings that the authors of this paper want to share with peer educators. First of all, to build a collaboration link between K-12 educators and university professors is very necessary. As computer techniques push science project to a historical high level, most of the engineering knowledge behind the project implementation needs support from higher education. In this weather balloon project, realizing lack of skills on computer system hardware connections and software designing, the middle school teachers sought help from university professors. To accomplish the goal, university faculty members provided their expertise in the system design. Collaboration was established at the beginning of the project. On the other hand, STEM educators should take a look at how the idea of STEM is received by K-12 students and figure out whether lacking of enrollment in specific program is caused by short of knowledge in specific area. For example, CPEG is relatively new program compared to other engineering programs. Although the computer engineering knowledge is widely used in our everyday lives, most middle school and high school students still don't know about it. If no one from university level introduces the program and fills in the gap, there is no way for the next generation youngsters to choose CPEG as their majors. Nowadays most students already have a dominated program in their mind before they become high school seniors. From university recruit point of view, STEM programs must find ways to attract them at an early stage.

In summary, this collaborated weather balloon project not only breaks the technical barriers for middle school teachers, but also provides university professors a unique opportunity to teach the middle school students what is Computer Engineering, as well as STEM. The collaboration platform provides the opportunity for the program to advertise to the community, as well as helps

the middle school teachers and students understand the nature of CPEG program, which further will benefit the program's recruitment in the future.

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